Reed Canarygrass in Alaska: Influence of Latitude-of-Adaptation on Winter Survival and Forage Productivit and Observations on Seed Production

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Summary

North American strains of reed canarygrass (*Phalaris arundinacea L.*) frequently sustain severe winter injury or total winterkill in southcentral Alaska. Objectives of this study were to compare reed canarygrass strains adapted to extreme northern latitudes in Europe with North American cultivars for winter-hardiness and forage production in Alaska.

The strains 'Rovik' and 'Hansvoll' from 69° to 70° N latitude in Norway were markedly superior in winter survival to 10 North American cultivars in all experiments, and more winter-hardy than nine other north-European accessions from 55° to 60° N in two experiments. Rovik and Hansvoll survived well through four consecutive winters, including one beyond termination of the experiments. Two accessions from northern sources in the Soviet Union were intermediate in winter-hardiness between those from northern Norway and three somewhat less hardy USSR accessions and one from Sweden; all of the accessions from Norway, the Soviet Union, and Sweden surpassed the less hardy strains from Denmark and North America in winter survival. In one experiment, a reed canarygrass from above 61° N in Canada was much less winter-injured than the more southern-adapted North American strains.

Seeding-year forage yields of the Norwegian strains were lower than the 10 North American reed canarygrass cultivars, and second-year yields of the Norwegian strains were lower than most of the non-*Phalaris* grasses compared. Nonetheless, the vastly more winter-hardy Norwegian strains reveal that a previously untapped reservoir of northern-adapted reed canarygrass germplasm exists for use in Alaska.

The introductions evaluated in this study and future accessions of reed canarygrass from far-northern European and North American sources should provide more dependably winter-hardy germplasm of this species than North American cultivars for the considerable areas of poorly drained and moderately acidic soils in Alaska for which most other forage or soil stabilization grass species are poorly suited.

Characteristics

Reed canarygrass (*Phalaris arundinacea L.*), a tall-growing, cool-season, leafy, sod-forming, perennial (Figure 1) is indigenous to North America, Europe, and Asia (Hanson, 1972; Hulten, 1968; Marten, 1985; Smith et al., 1986). Where adapted, it produces high yields of forage on fertile soils and serves as pasture, hay, and silage (Decker et al., 1967; Marten, 1985; Smith et al., 1986).

The species has a very extensive root system and is very drought-tolerant on deep soils (Marten, 1985; Smith et al., 1986), but its natural habitat is poorly drained and low to wet areas subject to occasional flooding. Therefore, unlike most other forage species, reed canarygrass thrives on lowland soils; moreover, it is more tolerant of mild to moderate soil acidity than most other cultivated grasses. Because of its rhizomatous habit (active vegetative spreading by underground stems, called rhizomes, Figure 2), reed canarygrass is valued also for use as an effective soil binder for erosion control in waterways and gullies (Hanson, 1972; Marten, 1985; Smith et al., 1986). These characteristics suggest that reed canarygrass should be useful on the considerable extent of soils in Alaska that tend to be poorly drained and/or moderately acidic.

History of Use

Reed canarygrass has a long history of utilization; the earliest recorded use as a forage crop was in Sweden in 1749 (Alway, 1931). It was used in England by 1824 and in Germany near 1854. About the same time it was recommended in Massachusetts for use by farmers as a component in mixtures seeded on peaty and marshy lands subject to flooding. A planting was reported in Oregon in 1885, and numerous seedings were made in Minnesota and Wisconsin near 1900 (Marten, 1985; Smith et al., 1986).

Palatability and Nutritive Value

Numerous reports of experimental studies and grower experience with reed canarygrass as pasture, as harvested forage, and as evaluated in feeding trials have been reviewed by others (Decker et al., 1967; Marten, 1985). Some disagreement on palatability and animal performance has been attributed to evaluations at different stages of growth; palatability and forage quality tend to decline rapidly at advanced stages of growth. Conse-

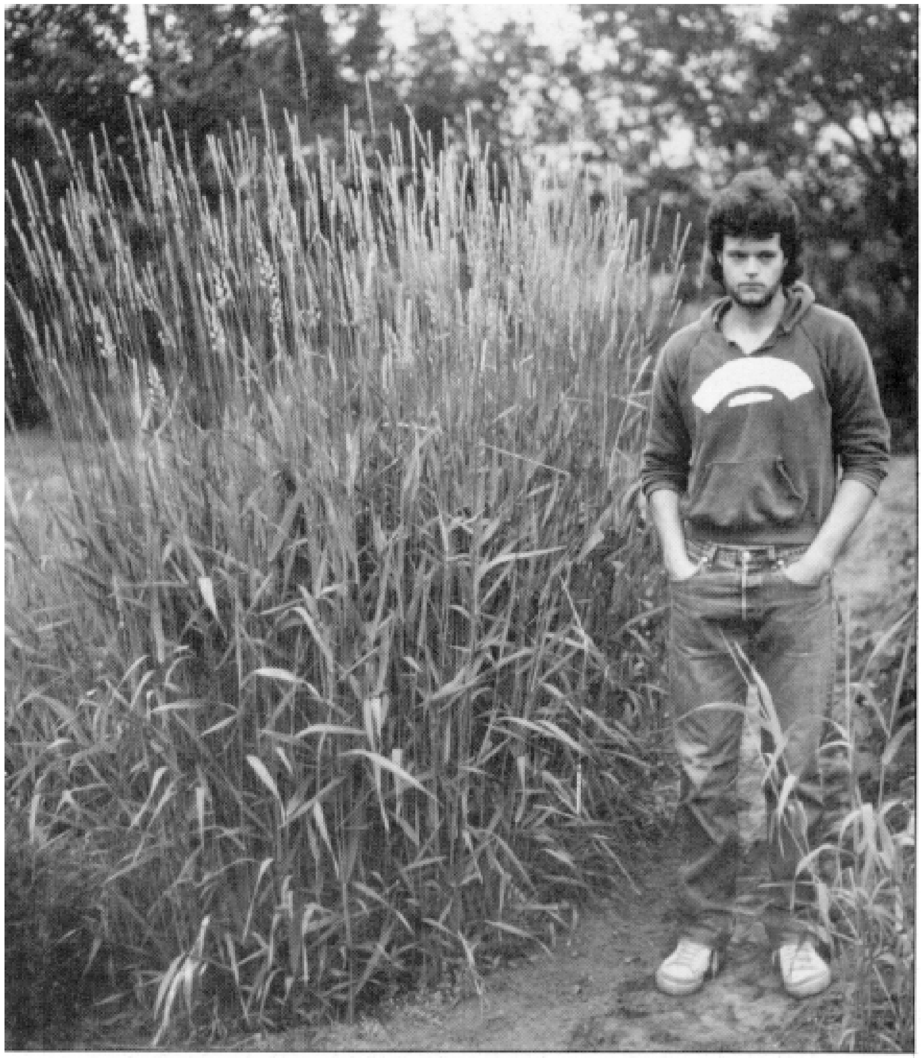


Figure 1. *A single, several-year-old plant of reed canarygrass at the Alaska Plant Materials Center near Palmer, showing the tall, leafy growth achieved by mid-season. Photo taken 28 July.*

quently, when utilized for pasture, stocking rate must be manipulated to keep the grass grazed down to about 12 inches, a more leafy and palatable stage than taller, more stemmy growth (Smith et al., 1986).

Beyond physical growth characteristics, however, chemical composition of herbage has been identified in recent years as having a major influence on palatability and animal performance (Marten, 1985). Palatability declined and daily weight gains of lambs and steers were lowered when animals grazed reed canarygrass that was high in total indole alkaloid concentration. Sheep were found to be more sensitive to this palatability problem than cattle. Diarrhea of livestock grazing high-alkaloid plants was a problem with tryptamine-carboline alkaloids but was reduced or absent when plants were consumed that contained gramine as the only indole alkaloid.

Marten et al. (1973) reported on nine clones of reed canarygrass grown in four widely separated states including Alaska where plants were grown at the Fairbanks Agricultural and Forestry Experiment Station. They concluded that the different growing environments associated with the diverse geographic areas did not greatly affect alkaloid type or the relative concentration of alkaloids among the plants.

Marten (1985) reported substantial progress in resolving these long-standing problems with reed canarygrass. He stated that the considerable genetic diversity among plants and the high herita-

Figure 2. *Close-up view of the crown area of a spring-planted (31 May) reed canarygrass seedling washed free of soil and photographed on 7 September. Robust underground stems (rhizomes) that appear white are actually light pink in color; these accomplish horizontal vegetative spread of the plant to produce a sod and, when they emerge from the soil surface, give rise to tillers that elongate during the same or the following growing season to become aerial stems (culms).*

bility of alkaloid concentration in this species have permitted selection of improved strains and cultivars characterized by enhanced palatability, therefore improved animal performance.

Improvement and Cultivar Selection

Although reed canarygrass is native across northern U.S. and areas of Canada, Smith et al., (1986) report that "the aggressive European type is the one widely grown in the United States rather than the native." Hanson (1972), however, states that the Canadian cultivars 'Frontier' and 'Grove' were derived from native collections.

Few improved cultivars of reed canarygrass were released prior to 1970. Since then, however, several have appeared; these incorporate characteristics such as improved seed retention, enhanced palatability, and superior nutritive value (Hanson, 1972; Marten, 1985).

Evaluations in Alaska

Marginal to poor winter-hardiness of all strains evaluated previously in Alaska has been a deterrent to significant use of the species in this state. Irwin (1945) summarized early experimental evaluations of many grasses in Alaska at seven widely dispersed experiment stations ranging from 57° to 65.5° N latitude. Earliest plantings of reed canarygrass were in 1905 at Kenai and in 1906 at the Rampart station on the Yukon River in interior Alaska. Those were the only recorded evaluations of the species at those stations and both plantings winter killed the first winter.

Only six other experimental trials were planted with this grass in Alaska prior to 1945; those were between 1932 and 1940 at the Matanuska and Fairbanks stations and winterkill usually was complete during the first or second winters. Sources of seed and latitudinal adaptation of reed canarygrass strains used in those early trials are not known with certainty; however, they probably were obtained through U.S. Department of Agriculture sources in the eastern USA or through commercial sources in the Pacific Northwest states.

From 1945 to 1984, Alaska Experiment Station records show seed importations for trials of reed canarygrass cultivars 'Ioreed', 'Superior', 'Rise', Frontier, and Grove, as well as non-cultivar commercial seed from the conterminous states and Canada. All of those cultivars and strains from the northern states or southern Canadian provinces generally have overwintered poorly in southcentral Alaska. There is a tendency toward somewhat better winter survival of North American reed canarygrass on Alaska's more southern and coastal Kenai Peninsula where winter stresses are somewhat milder than in the Matanuska Valley (Klebesadel, 1983).

Occasional roadside patches of introduced reed canarygrass occur in agricultural areas of Alaska (Hulten, 1968; Porsild and Cody, 1980) where it has escaped from earlier cultivation attempts. Though persistent in this non-stressful habitat, grass seed collected from roadside stands and grown in croplands exposes the grass to greater winter stresses and it has winter killed (Unpublished information, Alaska Agricultural and Forestry Experiment Station).

The northwestern limits of the native range of reed canarygrass in North America apparently reache coastal, southeastern Alaska (Hulten, 1968; Porsild and Cody, 1980). However, ecotypes from such areas with modest winter stresses undoubtedly would not be winter-hardy in this area (Klebesadel, 1985b).

Work with several other forage species in Alaska (Klebesadel, 1984, 1985a, 1985b; Klebesadel et al., 1964; Klebesadel and Helm, 1986) has demonstrated that cultivars and strains from northernmost origins, especially areas characterized by severe winter conditions, are most winter-hardy in this area. The senior author was privileged to attend in 1983 an international symposium in northern Norway on the subject of plant adaptation at northern latitudes. Upon arrival at Tromsø, Norway (69°40'N), reed canarygrass was noted to occur commonly there in a locality some 220 miles north of the Arctic Circle. Tromsø is about 560 miles north of the latitude of the Matanuska Valley where culture of North American reed canarygrass generally has been unsuccessful. Accordingly, contacts were established to secure seed of Norwegian strains for evaluation in Alaska.

The reed canarygrass strains obtained, 'Rovik' and 'Hansvoll', are adapted in northern Norway. Seed of those and of nine other numbered accessions from between 55° and 60° N in Denmark, Sweden, and the Soviet Union was obtained for evaluation. A collection of seed was obtained also from reed canarygrass growing at 61°52'N in Canada. Those and most of the currently available cultivars of reed canarygrass from North America were compared for winter-hardiness and forage production with other winter-hardy, non-Phalaris grass cultivars in experiments reported here.

Seed Production

In many areas of reed canarygrass utilization seed crops historically were harvested from native stands. However, with seed increase of new cultivars, and because no native stands of reed canarygrass exist in this area of Alaska, such situations require stand establishment for seed production.

Reported seed yields, whether from rows or from solid stands, vary over a considerable range (Marten, 1985; Baltensperger and Kalton, 1958). A major problem with seed production of this species is the uneven ripening of seed heads (Figure 3) and the ease with which seed "shatters" or is dropped from seed heads near maturity (Marten, 1985; Wilkins and Hughes, 1932). The earliest-maturing seed shatters before the bulk of the seed crop is at ideal stage for harvest. Accordingly, careful judgment is required in choosing harvest date, and some seed is invariably lost to shattering.

No previous investigations have been pursued on seed production of reed canarygrass in Alaska. Many management options require evaluation to arrive at optimum procedural steps to assure high seed yields.

Experimental Procedures

All experiments reported here were conducted at the University of Alaska's Matanuska Research Farm (61.6°N) in southcentral Alaska. Five field

Figure 3. *Appearance of seed heads of reed canarygrass at different stages of development. Left: As heads appear shortly after emerging; Center: Branches of seed head begin to spread as anthesis (flowering) begins; Right: Fully open seed head at full anthesis. At seed maturity, heads are again compact as the left one above and color has changed from greenish to tan.*

experiments were established in spring 1984 and one in spring 1986 in Knik silt loam (coarse-silty over sandy or sandy-skeletal, mixed, nonacid Typic Cryorthent). Commercial fertilizer disked into each plowed seedbed before planting supplied nitrogen (N), phosphorus (P), and potassium (K) at 32, 56, and 54 lb/acre. Randomized complete block experimental designs were used in all trials. A preemergence application of dinitro-o-sec-butylphenol (dinoseb) in water solution was sprayed onto each seedbed except Experiment 5 one-to-three days after planting to control broad leaf weeds.

Experiment 1: Fourteen reed canarygrass strains and eight comparison grasses in other species (listed in Table 1) were seeded at light rates in rows 25 feet long and 18 inches apart with six replications on 31 May 1984. When seedlings were 2-to-3 inches tall they were thinned by hand to leave individual seedlings 8-to-12 inches apart. Aerial growth on all plants was mowed and removed on 5 October 1984 and on 21 October 1985 leaving a 3-inch stubble to prevent uneven snow retention on rows during winter. On 30 April 1985 and on 13 May 1986 the entire experiment was topdressed with commercial fertilizer that supplied N, P, and K at 32, 56, and 53 lb/acre, respectively. When growth of surviving plants was well underway in 1985 and in 1986, living and dead plants were counted in each row to determine percent winter survival, and each living plant was rated for vigor.

Experiment 2: Twenty-two reed canarygrass strains were solid-seeded in rows 12 feet long and 18 inches apart with two replications on 5 June 1984. This test was in an exposed field area subject

Source	Strain	Latitudinal adaptation or origin	1985 Winter survival	1985 Vigor rating[1]	1986 Winter survival[2]	1986 Vigor rating[1]
Reed canarygrass:		°N	%		%	
Norway	Rovik	69-70	99 a[3]	5.4 f	98 a	3.4
	Hansvoll	69-70	94 b	5.5 f	100 a	3.0
Canada	Common	44-52	6 cde	9.0 g	0	-
	Castor	44-52	1 e	9.8 i	0	-
	Grove	44-52	1 e	9.8 i	0	-
	Frontier	44-52	0	-	-	-
USA	Vantage	41-44	9 c	9.2 gh	0	-
	Venture	41-44	7 cd	9.2 gh	0	-
	Ioreed	41-44	5 cde	9.2 gh	0	-
	MN-76	43-48	2 de	9.7 hi	0	-
	Palaton	41-44	2 de	9.3 ghi	0	-
	Flare	41-44	1 e	9.8 i	0	-
	Rise	41-52	0	-	-	-
	Superior	42-46	0	-	-	-
Other grasses:						
Norway	Lavang Kentucky bluegrass	69-70	100 a	2.5 b	100 a	1-2[4]
	Engmo timothy	69-70	100 a	3.6 de	100 a	3.1
Alaska	Polar bromegrass	61.6	100 a	1.8 a	100 a	1-2[4]
	Arctared red fescue	61.6	100 a	2.2 ab	100 a	1.8
	Nugget Kentucky bluegrass	61.6	100 a	3.1 cd	100 a	2.2
Canada	Dormie Kentucky bluegrass[5]	69	98 a	2.6 bc	100 a	1-2[4]
USA	Garrison creeping foxtail	45-52	99 a	3.3 d	100 a	1-5[4]
	Manchar bromegrass	43-47	98 a	4.0 e	100 a	1-2[4]

[1] Means of ratings of all living plants: 1 = excellent survival and vigor, 9 = minimal vigor, barely alive (some means exceed 9.0 due to total winterkill in some replicates).

[2] Percent survival in 1986 of plants alive in 1985.

[3] Within each column, means not followed by a common letter are significantly different (5% level) using Duncan's Multiple Range Test.

[4] Rating of individual plants no longer possible; adjacent plants had coalesced due to active vegetative spread; values shown are estimated range of vigor ratings.

[5] Selected in Canada from germplasm originating in the Murmansk region of the USSR (69°N).

Table 1. *Percent winter survival of 14 reed canarygrass strains from diverse latitudinal origins and eight winter-hardiness comparison grasses in other species grown as individual plants in rows in an exposed location at the Matanuska Research Farm (61.6°N). Experiment 1; planted 31 May 1984.*

Source	Strain	Latitudinal adaptation or origin	Exposed site		Protected site: Ice-covered replicate		Protected site: Replicate not ice-covered	
			Winter 1984-85	19 June 1986	Winter 1984-85	19 June 1986	Winter 1984-85	19 June 1986
		°N	% winter survival	% of original stand	% winter survival	% of original stand	% winter survival	% of original stand
Norway	Rovik	69-70	89 a[1]	98 a	95	100	100	100
	Hansvoll	69-70	83 a	95 a	95	100	100	100
USSR	PI-369291	55.3	20 b	80 ab	40	85	95	100
	PI-345662	59.9	20 b	85 a	40	85	90	95
	PI-209979	(?)	13 bc	58 bc	35	90	90	100
	PI-369292	55.3	8 bc	13 e	25	80	70	80
	PI-406316	59.9	6 c	20 de	10	45	70	90
Sweden	PI-235547	59.9	6 c	40 cd	35	95	70	90
Denmark	PI-234694	55.7	1 c	4 e	2	5	65	90
	PI-235551	55.1	0	--	10	30	55	95
	PI-234697	60.4	0	--	2	5	25	70
Canada	Castor	44-52	2 c	2 e	5	15	70	90
	Grove	44-52	1 c	1 e	5	10	60	90
	Frontier	44-52	0	--	1	2	65	90
USA	Rise	41-52	1 c	3 e	20	50	95	95
	Palaton	41-44	1 c	0	10	5	90	95
	Venture	41-44	1 c	0	25	10	75	80
	Vantage	41-44	1 c	1 e	10	15	85	95
	Ioreed	41-44	1 c	1 e	10	20	80	95
	Flare	41-44	1 c	1 e	5	5	75	80
	MN-76	43-48	0	--	0	--	15	40
	Superior	42-46	0	--	0	--	1	5

[1] Within each column, means not followed by a common letter are significantly different (5% level) using Duncan's Multiple Range Test.

Table 2. *Visual estimates of comparative winter survival and stand filling among reed canarygrass strains from diverse latitudinal and geographic origins grown in solid-seeded rows in exposed and protected field sites at the Matanuska Research Farm (61.6°N). Experiments 2 and 3; planted 5 and 7 June 1984.*

Source	Strain	1984 26 Sep	1985 9 July	1985 11 Sep	1985 Total		1986 30 June	1986 10 Sep	1986 Total	Three-year total
Reed canarygrass		Tons per acre								
Norway	Rovik	1.37 i-l[1]	1.01 g	0.74 de	1.75 g		1.02 def	1.58 d	2.60 e	5.72 g
	Hansvoll	0.76 m	0.40 h	0.51 ef	0.91 h		0.40 g	1.11 e	1.51 f	3.18 hi
Canada	Frontier	2.66 abc	Tr[2]	Tr	Tr	(WK)[3]	--	--	--	2.66 ijk
	Castor	2.38 b-e (WK)	--	--	--		--	--	--	2.38 ijk
	Grove	2.04 d-g (WK)	--	--	--		--	--	--	2.04 jk
USA	Palaton	3.03 a	Tr	Tr	Tr	(WK)	--	--	--	3.03 hi
	Venture	2.81 ab	Tr	Tr	Tr	(WK)	--	--	--	2.81 hij
	Ioreed	2.58 abc	Tr	Tr	Tr	(WK)	--	--	--	2.58 ijk
	Vantage	2.55 abc	Tr	Tr	Tr	(WK)	--	--	--	2.55 ijk
	Rise	2.47 bcd	Tr	Tr	Tr	(WK)	--	--	--	2.47 ijk
	Flare	2.30 c-f	Tr	Tr	Tr	(WK)	--	--	--	2.30 ijk
	MN-76	1.86 f-i (WK)	--	--	--		--	--	--	1.86 jk
Other grasses:										
Norway	Lavang Kentucky bluegrass	1.05 lm	2.59 a	0.90 cd	3.49 a		2.41 a	1.07 e	3.48 ab	8.02 a-d
	Lofar bromegrass	1.88 e-i	2.15 b	0.89 cd	3.04 abc		1.41 c	1.86 a-d	3.27 a-d	8.19 abc
	Engmo timothy	2.05 d-g	1.16 fg	0.83 cd	1.99 fg		1.06 def	1.92 a-d	2.98 b-e	7.02 ef
	Salten meadow fescue	1.73 g-k	0.47 h	1.44 a	1.91 g		Tr	Tr	Tr	3.64 h
	Salten II meadow fescue	1.45 h-l	0.58 h	1.18 b	1.76 g		Tr	Tr	Tr	3.21 hi
	Hattny orchardgrass	1.70 g-k	Tr	0.42 f	0.42 i	(WK)	--	--	--	2.12 jk
	Hattfjeldal orchardgrass	1.80 f-j	Tr	0.13 g	0.13 i	(WK)	--	--	--	1.93 jk
Iceland	Adda timothy	1.93 e-h	1.20 fg	0.82 cd	2.02 fg		1.17 cde	1.96 a-d	3.13 cde	7.08 def
Alaska	Arctared red fescue	1.21 klm	2.16 b	1.08 bc	3.24 ab		1.76 b	1.63 cd	3.39 ab	7.84 a-e
	Polar bromegrass	1.89 e-i	2.15 b	0.87 cd	3.02 abc		1.74 b	1.97 a-d	3.71 a	8.62 a
	Nugget Kentucky bluegrass	1.22 klm	1.35 efg	1.46 a	2.81 bc		1.31 cd	2.00 abc	3.31 abc	7.34 cde
	Pumpelly bromegrass[4]	1.92 e-h	1.72 cd	1.04 bc	2.76 bcd		1.22 cde	1.79 bcd	3.01 b-e	7.69 a-e
	Quackgrass[5]	1.68 g-k	1.58 cde	0.70 de	2.28 d-g		1.16 cde	2.07 ab	3.23 a-d	7.19 de
Canada	Commercial bromegrass	1.97 e-h	2.07 b	0.88 cd	2.95 bc		1.18 cde	2.24 a	3.42 ab	8.34 ab
	Carlton bromegrass	1.77 g-j	1.84 bc	0.83 cd	2.67 cde		1.13 cde	2.07 ab	3.20 a-d	7.64 b-e
USA	Manchar bromegrass	1.55 g-k	1.66 cde	0.87 cd	2.53 c-f		0.94 ef	2.07 ab	3.01 b-e	7.09 cde
	Signal bromegrass	2.50 bcd	1.42 def	0.74 de	2.16 efg		0.78 f	1.95 a-d	2.73 de	7.39 b-e
	Garrison creeping foxtail	1.33 jkl	1.09 fg	0.99 bcd	2.08 fg		0.90 ef	1.92 a-d	2.82 cde	6.23 fg

1 Within each column, means not followed by a common letter are significantly different (5% level) using Duncan's Multiple Range Test.
2 Trace amount of herbage inadequate for harvestable yield.
3 No further yields; stand winterkilled completely.
4 Composited line representing several indigenous Alaskan collections.
5 Grown from seed collected from a local, naturalized population.

Table 3. *Seeding-year and subsequent oven-dry forage yields over two years of 12 reed canarygrass strains from various world sources, and 18 northern-adapted non-Phalaris grasses at the Matanuska Research Farm. Experiment 4 ; broadcast-seeded plots planted 24 May 1984.*

to maximum winter stress; strains used and results are reported under "exposed site" in the text and in Table 2. Aerial growth on all rows was clipped and removed on 9 October 1984 and on 16 October 1985 leaving a 3-inch stubble. Topdressings of commercial fertilizer in springs of 1985 and 1986 were applied on the same dates and at the same rates as in Experiment 1. In spring of 1985 all rows were rated for estimated percent winter survival; in spring of 1986 all rows were rated for estimated percent of full original stand.

Experiment 3: The same 22 strains used in Experiment 2 were solid-seeded in rows 12 feet long and 24 inches apart with two replications on 7 June 1984 in a less-exposed field site. This experiment (referred to as "protected site" in the text and in Table 2) was in the lee of a wooded tract and consequently was not subject to wind removal of snow cover during winter. Topdressings of commercial fertilizer in springs of 1985 and 1986 were applied on the same dates and at the same rates as in Experiment 1. Each row was rated in spring of 1985 and 1986 as were the rows in Experiment 2.

Experiment 4: Twelve reed canarygrass strains were broadcast-seeded in plots 18 feet long and 5 feet wide with four replications on 24 May 1984. Eighteen northern-adapted non-*Phalaris* grass cultivars listed in Table 3 were planted for winterhardiness and forage-production comparisons; cultivar or common names appear in Table 3. Non-Phalaris species included in this test, and seeding rates in pounds per acre were (some of these species also were included in Experiments 1 and 5): Kentucky bluegrass (*Poa pratensis L.*) = 26, timothy (*Phleum pratense L.*) = 8, meadow fescue (*Festuca elatior L.*) = 22, red fescue (*F. rubra L.*) = 26, orchardgrass (*Dactylis glomerata L.*) = 22, creeping foxtail (*Alopecurus arundinaceus Poir.*) = 22, quackgrass (*Agropyron repens (L.) Beauv.*) = 25, pumpelly bromegrass (*Bromus pumpellianus Scribn.*) = 22, and smooth bromegrass (*B. inermis Leyss.*) = 22. 'Polar' bromegrass is predominantly of hybrid origin between smooth and pumpelly bromegrasses. All broadcast-seeded plots of reed canarygrass were planted at 26 lb/acre.

All plots were harvested for seeding-year forage yields on 26 September 1984. On 30 April 1985 and on 13 May 1986, commercial fertilizer topdressed uniformly on all plots supplied N, P, and K at 126, 42, and 40 lb/acre, respectively. Shortly after the first-cutting forage harvest in 1985 and 1986, ammonium nitrate topdressed uniformly on all plots supplied N at 85 lb/acre. Forage harvests were on 9 July and 11 September in 1985, and on 30 June and 10 September in 1986. Harvest procedures were as described previously (Klebesadel, 1985a). All forage yields are reported on the oven-dry basis (140°F).

Experiment 5: Twelve reed canarygrass strains and 11 northern-adapted comparison grasses were seeded at light rates in rows 24 feet long and 18 inches apart with six replications on 14 May 1986. Included in this experiment, but not in the earlier-planted ones, were 'Norcoast' hairgrass (*Deschampsia beringensis Hulten*) and a collection of reed canarygrass from Fort Simpson, Northwest Territories, Canada, a location at 61°52'N, and among the northernmost occurrences of reed canarygrass in Canada (Porsild and Cody, 1980). The small seed lot received in September 1982 was seeded in a row on 16 July 1983 with seed increases harvested in 1984 and 1985 for use in this experiment (Figure 4).

When seedlings were 2-to-3 inches tall they were thinned by hand to leave individual seedlings 8-to-12 inches apart. All aerial growth was clipped to a 3-inch stubble and removed from the experiment on 15 October 1986. In early June of 1987, living and dead plants were counted in each row to determine percent winter survival, and each living plant was rated for vigor. Mean number of plants per row in the entire experiment was 27.

Experiment 6: Rovik reed canarygrass was seeded in 30 rows 60 feet long and 24 inches apart on 1 June 1984. The entire area was treated uniformly with spring topdressings of N, P, and K at 32, 56, and 54 lb/acre on 23 May 1985 and 13 May 1986, and seed crops were harvested on 16 August 1985 and 5 August 1986. On 5 August 1986, the area was divided into 8 experimental plots, each measuring 7 by 60 feet, with the long dimension of plots oriented across all 30 rows. On 6 August 1986, all aerial growth on four of the plots was clipped to a 3-inch stubble and removed. On the same date, two of the clipped and two of the

Figure 4. *Individual plants of the Ft. Simpson ecotype of reed canarygrass grown for seed increase. Photo taken 14 August 1985 at harvest of earliest-ripened seed heads; row seeded 16 July 1983.*

undisturbed plots were topdressed with ammonium nitrate to supply N at 100 lb/acre.

On 27 April 1987, the four plots unclipped in 1986 were clipped to a 3-inch stubble and the strawy growth removed. On 5 May 1987, the four plots not topdressed on 6 August 1986 were topdressed as the others had been in 1986. On 17 August 1987, a sickle mower was used to clip a swath 2 1/2 feet wide and centered on all plot boundaries to remove border effects. This growth was discarded. Seed was harvested from all plots with hand sickles on the same date, the bagged heads were dried at room temperature, threshed, the cleaned seed lots weighed, and yields per acre calculated.

Results and Discussion

All grasses established well in all experiments with the single exception of less vigorous seedlings and fewer seedlings per row of the US cultivar Superior in Experiments 2 and 3 (Figures 5 and 6). A heavy seeding rate used for the low-germination seed lot did not adequately compensate to produce a full stand. Additionally, a curious anomaly was noted in differential reaction among reed canarygrass strains to the pre-emergence herbicide used. Dinoseb has been used without injury to North American strains of reed canarygrass in past years, and none showed injury in the 1984 plantings. In contrast, very obvious herbicidal injury was apparent to the Norwegian reed canarygrass strains Rovik and Hansvoll. Many of the earliest seedlings whitened and died and stands were very slow to establish from later germinating seeds. These effects were more apparent in the broadcast plots (Experiment 4) than in the row seedings of Experiments 1, 2 and 3.

Experiment 1: *Reed Canarygrass Strains and Other Grasses as Individual Plants in Rows 1984-86.*

The exposed location and short stubble left in autumn of 1984 and 1985 in this experiment ensured maximum exposure of plant crowns to winter stresses. When winter survival counts were made in late May 1985, all North American strains of reed canarygrass were rated as 100% winterkilled. Very slow recovery of a few plants during the growing season, however, prompted second

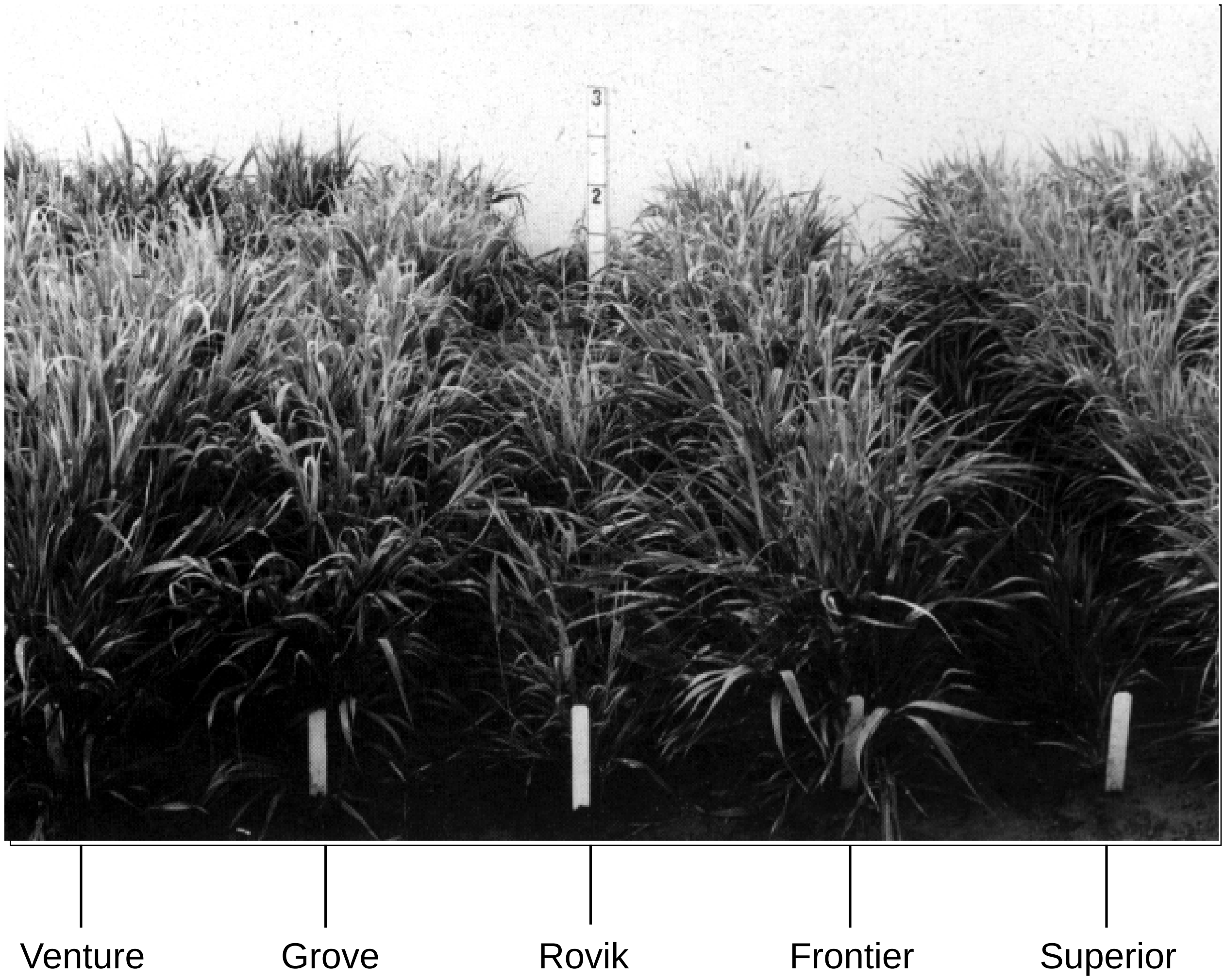


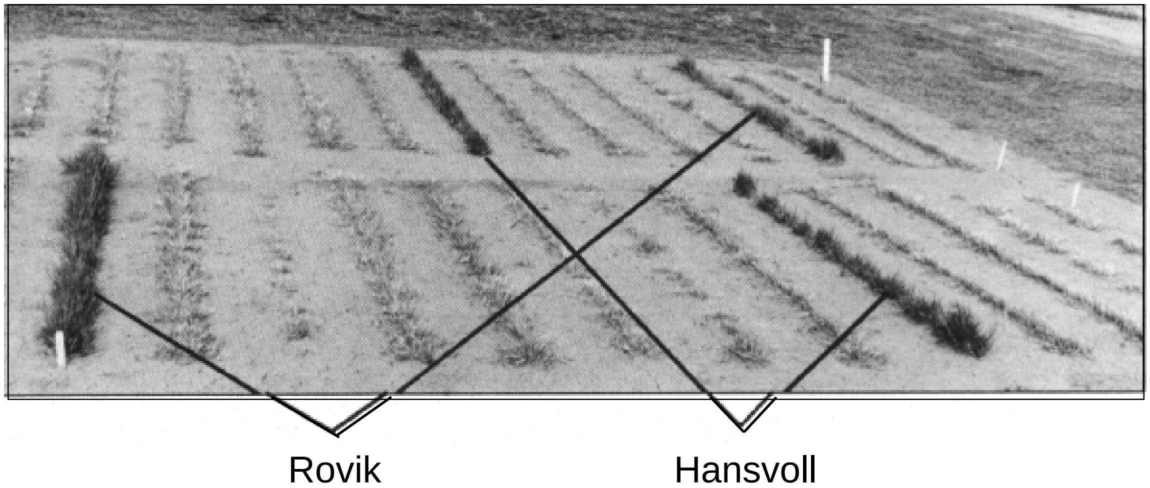
Figure 5. *A portion of Experiment 2 showing reed canarygrass cultivars in rows and seeding-year growth achieved by 9 October 1984. White board behind stake obscures second set of rows; numbers on stake indicate height in feet.*

counts and those data appear in Table 1. Despite some late-appearing growth on a few plants, winter survival of all North American strains of reed canarygrass was very poor (mean = 3%). Moreover, ratings of vigor of surviving plants also were much poorer than in the other grasses compared, due to severe winter injury (Table 1). No plants of any of the 12 North American strains of reed canarygrass survived the 1985-86 winter.

Rovik and Hansvoll reed canarygrass from northern Norway survived both winters markedly better (94% to 100%) than the Northern American strains (Table 1; Figure 7). Vigor ratings of Rovik and Hansvoll plants were intermediate between the non-hardy reed canarygrass strains and the more winter-hardy non-*Phalaris* grasses in spring of 1985, indicating some winter injury to the Norwegian reed canarygrass strains. The two Norwegian strains rated somewhat better in vigor in spring 1986 than in 1985 as the second winter (1985-86) was slightly less stressful on plants. All of the non-*Phalaris* grasses showed excellent winter survival and sustained little injury during either winter as indicated by good vigor ratings (Table 1).

Although no survival or vigor ratings were recorded in spring of 1987, virtually all of the Rovik and Hansvoll plants appeared to have survived the third winter.

Experiments 2 and 3: *Reed Canarygrass Strains in Rows in Exposed vs. Protected Field Sites.*



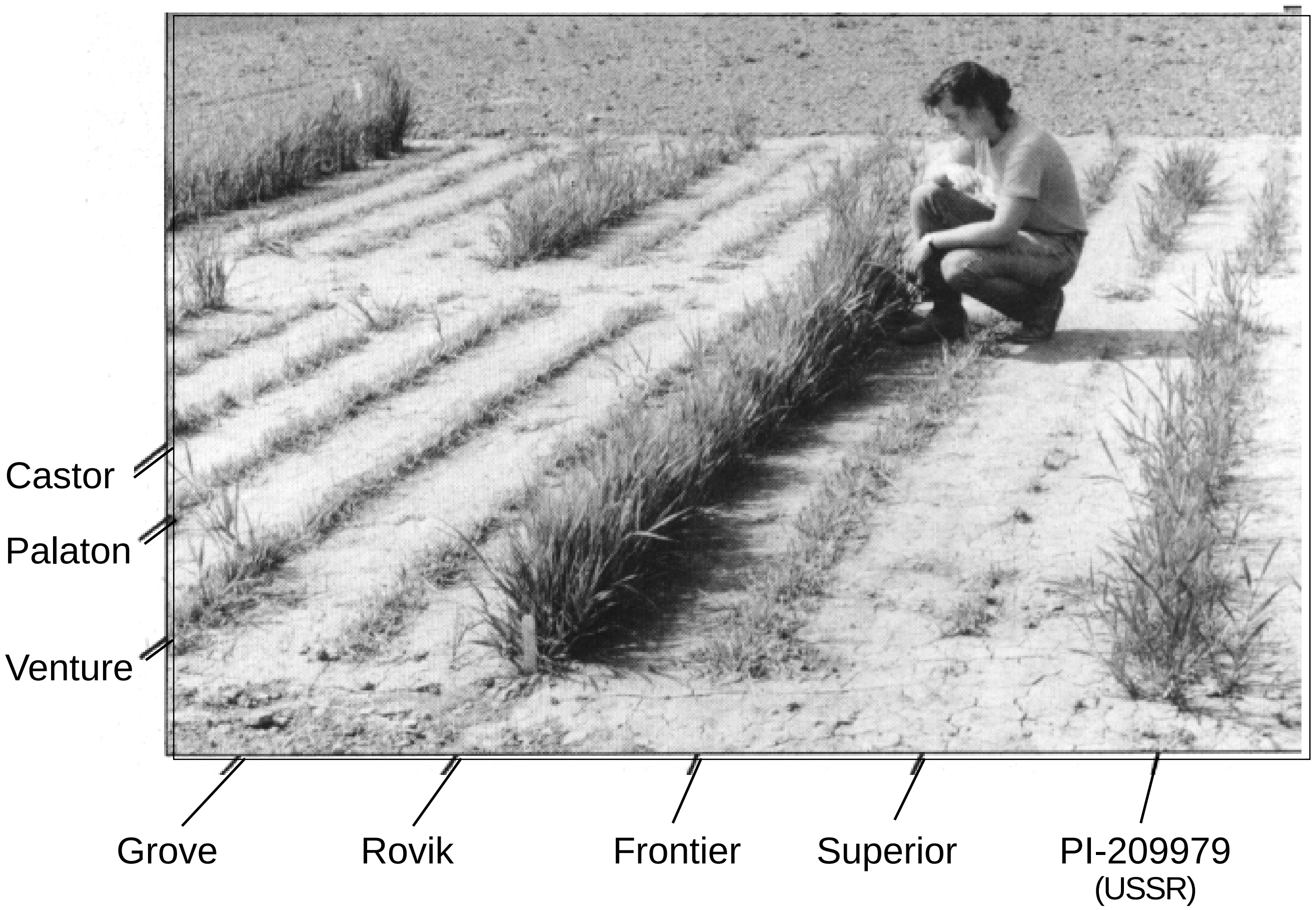


Figure 6. *Upper photo: Solid-seeded rows of reed canarygrass strains in Experiment 2 photographed 31 May 1985 showing extensive winter injury of most strains, versus superior survival of Rovik and Hansvoll. Lower photo: The same experiment near mid-July 1985 showing gradual recovery of some strains.*

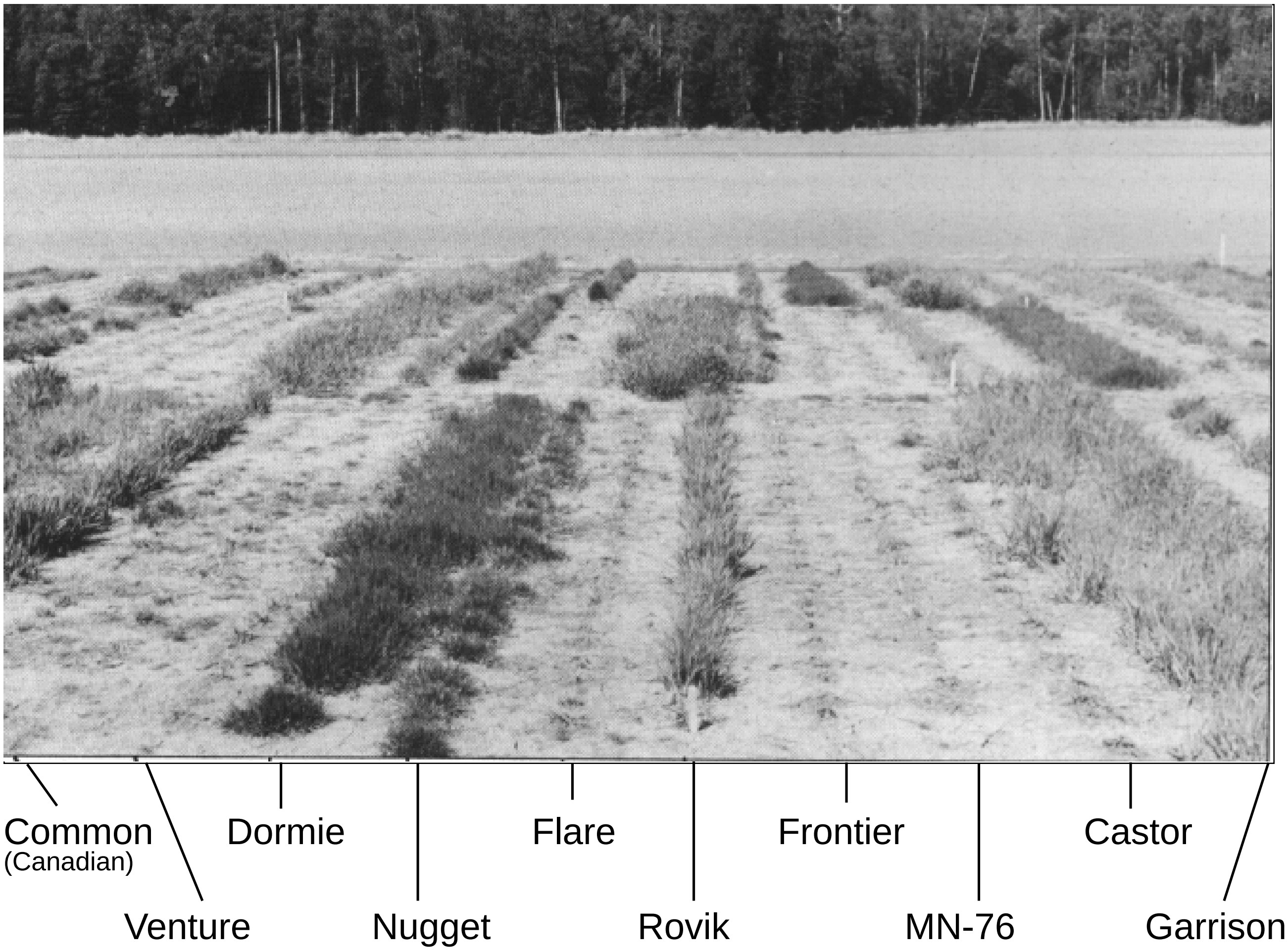


Figure 7. *A portion of Experiment 1 showing appearance on 28 May 1986 of individual plants in rows following two winters in a field area exposed to maximum winter stress.*

The range in percent winter survival among the 22 strains of reed canarygrass in solid-seeded rows was great, and survival was markedly influenced by field location of experiments that in turn influenced exposure of plants to winter stresses (Table 2). Winter survival again was related generally to latitudinal origins of strains. The two Norwegian strains from extreme northern origins were much superior to all other entries from more southern sources (Figure 6), with greatest differences where exposure increased the severity of winter stresses.

In the exposed-site experiment, estimates of percent winter survival of North American cultivars were 2% or less. Similarly, winter survival of accessions from Denmark was very poor. Even though those three strains derived from more northern latitudes (55° to 60° N) than the North American strains, winter stresses in Denmark apparently are too mild to confer high levels of winter-hardiness in strains originating there. The single accession from Sweden generally was similar in hardiness to the three least-hardy accessions from the USSR. These results parallel the generally poor winter survival noted previously in southcentral Alaska of Swedish cultivars of Kentucky bluegrass, red fescue, meadow fescue, and timothy (Klebesadel, 1984, 1985a; Klebesadel et al., 1964; Klebesadel and Helm, 1986).

A greater range in percent winter survival was seen in accessions from the USSR. The least hardy strain survived at 6% and the two most winter-hardy were rated at 20% survival in spring of 1985; the latter two were significantly less winter-hardy than the two Norwegian strains, but survived significantly better than the 18 other strains from Europe and North America. With recovery during 1985, and a somewhat less severe subsequent winter (1985-86), the same two USSR strains were rated as 80% and 85% of full stands in spring of

1986 (Table 2). Superior survival of some USSR strains over those from similar latitudes in Denmark and Sweden probably is due to more severe winter stresses prevalent in the more continental origins of the USSR strains. Nonetheless, the USSR accessions, originating from between 55° and 60° N, were generally somewhat inferior in winter survival to the more northern-adapted Rovik and Hansvoll from 69° to 70° N in Norway.

The protected-site experiment was adjacent to a wooded tract and leeward from strong winter winds. Therefore, some snow cover protected the grass rows for a portion of the winter, providing considerably more protection from cold stress than in the exposed site and resulting in generally better winter survival (Table 2). However, an unplanned difference in winter conditions occurred in the protected-site experiment. One replicate was slightly and uniformly better drained than the other. When mild temperatures thawed the snow during the winter of 1984-85, it refroze as a layer of ice 2 to 4 inches thick on the poorly drained replicate and remained in place for over two months ("ice-covered" in Table 2). Similar ice covering did not occur during the winter 1985-86.

Although winter survival of most grasses was better in both replicates of the protected-site experiment than in the exposed site, survival in spring of 1985 was much poorer in the ice-covered replicate than in the one not subjected to ice coverage. In the latter replicate, several of the North American, Danish, and Swedish cultivars and accessions survived with relatively minor winter injury.

A comparison of the 1984-85 winter-survival percentages recorded in spring of 1985, and the percent of original full stand recorded in June 1986 (Table 2) in the exposed site and in the ice-covered replicate, reveals a marked ability of severely injured stands to recover. This was more true of the intermediately injured USSR and Swedish strains than the more-injured and less winter-hardy North American cultivars.

Near the end of each growing season, foliage on Rovik and Hansvoll, especially the former, was noted to become yellowed, bleached, and finally senescent and dried or "cured" (Figure 8). In contrast, leaf growth on all of the other less winter-hardy strains and cultivars remained green and succulent until killed by frost. This parallels observations by Baltensperger and Kalton (1958) in Iowa who found leaves of non-hardy accessions of reed canarygrass from more southern sources (Alabama and Arkansas) to remain darker green in October than the more northern-adapted, winter-hardy strains.

A similar relationship of foliar bleaching, latitudinal adaptation, and winter-hardiness has been noted in Alaska in red fescues (Klebesadel, 1985a; Klebesadel et al., 1964) and in slender wheatgrasses (*Agropyron trachycaulum (Link) Malte*) (Unpublished information, Alaska Agricultural and Forestry Experiment Station). This phenomenon is believed to indicate a photoperiodic-instigated early cessation of growth in the more northern-adapted strains that are better attuned to earlier preparedness for dormancy and onset of winter, a response critical to winter survival at northern latitudes (Klebesadel, 1985b).

Experiment 4: *Reed Canarygrass Strains and Other Grasses in Broadcast-Seeded Plots for Forage Production.*

Forage yields were favored during the seeding year (1984) by well distributed precipitation that was above normal in each of the months April through August. In contrast, precipitation in 1985 and 1986 was below normal four of those five months in both years. Total April through August precipitation totalled 8.64 inches in 1984, 0.80 inches above normal; for the same period in 1985, rainfall was 1.93 inches below normal and, in 1986, 1.06 inches below normal.

Seeding-year forage yields of all 12 North American cultivars of reed canarygrass were excellent and were generally higher than most of the other 18 grasses compared (Table 3). In contrast, the two northernmost-adapted reed canarygrass strains from northern Norway were among the lowest-yielding entries in the seeding year. To some extent, the lower yields of Rovik and Hansvoll were due to slower establishment owing to the aforementioned herbicidal injury effects but, in addition, they were considerably shorter in stature in the seeding year than the North American strains of reed canarygrass (Figure 9).

At harvest in late September, seeding-year height of all North American cultivars was 30 to 36 inches. In contrast, Rovik was 22 to 26 inches tall while Hansvoll plants, with least culm elongation

Figure 8. *Appearance of foliage on reed canarygrass strains on 4 October 1985 near termination of the growing season. Leaves on Rovik and Hansvoll from 69° to 70° N. have yellowed and dried, while growth on all other entries (all from south of 60° N.) remains green and succulent.*

and the highest proportion of lax leaf growth of all reed canarygrasses, were only 10 to 12 inches tall.

During the 1984-1985 winter, all of the North American strains of reed canarygrass were so severely injured that none recovered to produce measurable yields in 1985 (Figures 10 and 11). Other grasses severely injured were Hansvoll reed canarygrass and two meadow fescue and two orchardgrass cultivars, all from Norway; however, all five recovered to produce harvestable yields in 1985. Although Rovik sustained some winter injury, it significantly surpassed Hansvoll in first-cutting and in total forage yield in 1985, and in both cuttings and in total yield in 1986 (Table 3). Rovik produced significantly less than 10 other non-*Phalaris* grasses in the first cutting in 1985. In the second cutting, Rovik ranked 14th of the 30 grasses compared but yielded significantly less than only four of the other grasses. In total yields of 1985, Rovik ranked 16th but yielded significantly less than only eight of the other grasses. In 1986, only four grasses yielded significantly more forage than Rovik in the first cutting, and only five surpassed it by a significant margin in the second cutting.

Forage yields in 1986 generally were not greatly different for most of the very winter-hardy, non-*Phalaris* grasses from those in 1985. However, the more marginally winter-hardy grasses, such as the two reed canarygrass strains from northern Norway and the timothy cultivars Engmo from Norway and Adda from Iceland, benefited from the milder 1985-86 winter and averaged over 50% greater production in 1986 than in 1985.

The seven bromegrass strains were all included in the 11 highest-yielding grasses in 3-year totals. The least winter-hardy grasses in the experiment were the 10 North American reed canarygrass cultivars, the two Norwegian orchardgrass cultivars, and the two Norwegian meadow fescue cultivars; hence, all were low in 3-year total yields.

In 1985, most grasses produced more forage in

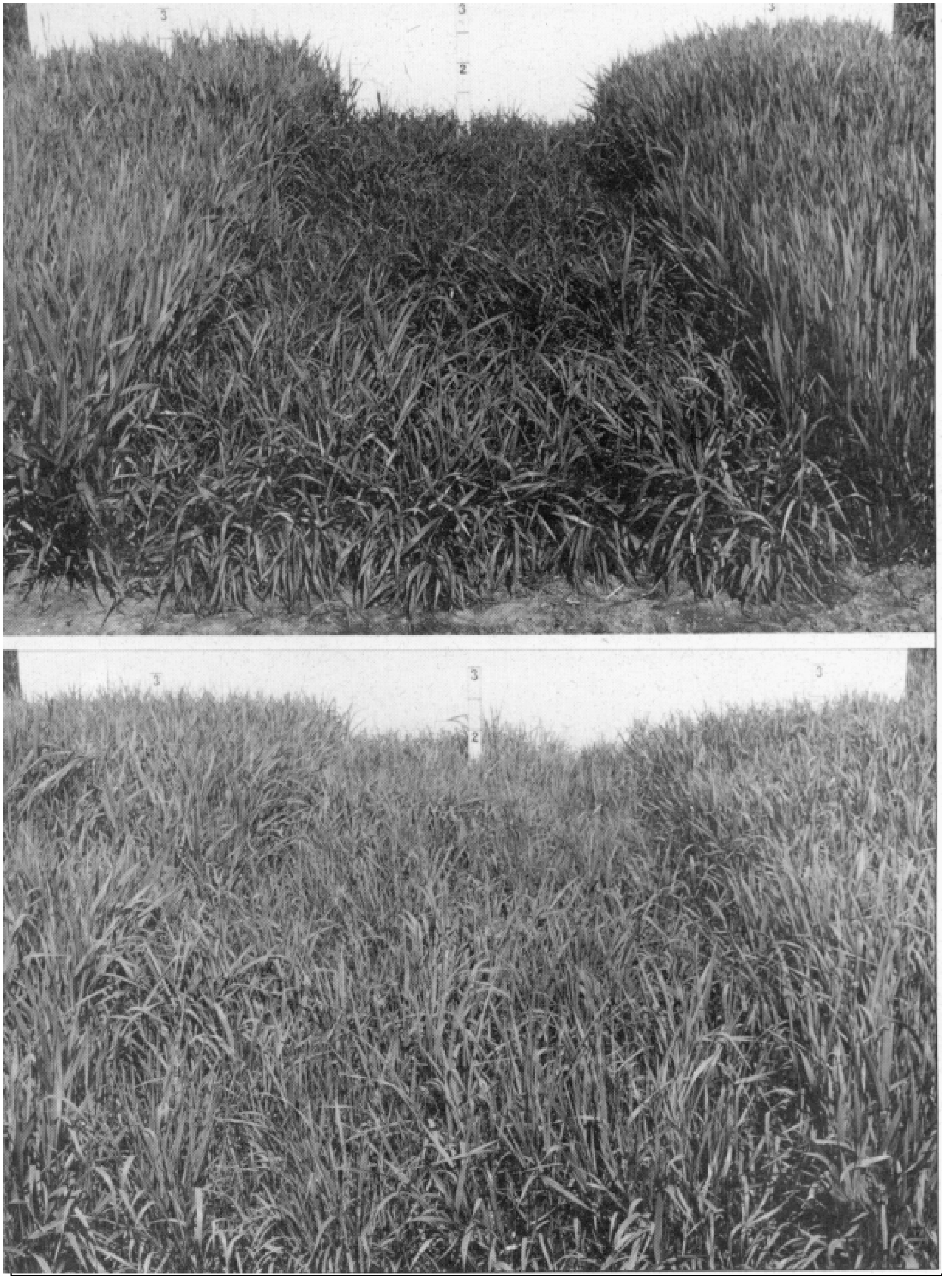


Figure 9. *Seeding-year growth comparisons of reed canarygrass strains. Left and right plots in upper photo are cultivars Flare and Palaton from the US Midwest; center plot is Hansvoll from northern Norway. Left and right plots in lower photo are cultivars Castor and Grove from Canada; center plot is Rovik from northern Norway. Numbers on white stakes indicate height in feet. Experiment 4; planted 24 May 1984; photo 16 Aug. 1984.*

Figure 10. *Comparative winter survival of plots of three broadcast-seeded reed canarygrass strains after the first winter in Experiment 4. Left and right plots in foreground are strains Hansvoll and Rovik, respectively, adapted at 69° to 70° N. in northern Norway; center plot is Canadian cultivar Frontier, adapted at 44° to 52° N. Experiment 4; planted 24 May 1984; photo 16 June 1985.*

the first cutting than in the second; in 1986 the reverse was true. The higher first-cutting yields in 1985 are believed due partly to a later first-cutting date, and partly to carry-over effect of moisture from above-normal precipitation during 1984. Moreover, despite otherwise limited precipitation during 1986, over four inches of rainfall in July helped increase second-cutting yields that year.

Below normal precipitation in 1985 and 1986 undoubtedly suppressed forage yields of all grasses in both years, the first cutting more than the second cutting in 1986. The above-normal precipitation in 1984, and below normal in 1985 and 1986, tend to distort forage-yield comparisons in the 3-year totals (Table 3); the 10 non-hardy reed canarygrass cultivars are somewhat disproportionately favored by the uneven moisture supply over the three years.

Experiment 5: *Reed Canarygrass Strains and Other Grasses as Individual Plants in Rows 1986-88.*

The winters of 1986-87 and 1987-88 were moderate in stress on overwintering plants. Although Experiment 5 was located in an exposed field environment, all non-*Phalaris* comparison grasses survived the 1986-87 winter at 100% and displayed excellent spring vigor (Table 4), indicating essentially no winter injury of the surviving plants.

The North American cultivars of reed canarygrass survived the 1986-87 winter much better than the winters of 1984-85 and 1985-86 (Experiments 1, 2, and 3). Percent winter survival of cultivars ranged from 40% to 94% while the "common" strain from Canada (specific latitude of culture and adaptation not known) survived at 96% (Table 4). The percent survival of plants of most North American strains, however, tended to be somewhat misleading, for plants were rated as living if only a single tiller survived. The vigor ratings (Table 4) and actual appearance of plants (Figure 12) confirm that virtually all North American strains sustained severe winter injury.

In contrast to other North American strains, the northernmost-adapted ecotype from Fort Simpson, N.W.T., survived well and was intermediate in vigor between other North American strains and the two strains from northern Norway (Table 4, Figure 12). The superior performance of this single collection from 61.9°N in Northwest Territories suggests that efforts should prove worthwhile in collecting more widely from far-northern occurrences of reed canarygrass in

Figure 11. *Comparative winter survival of three reed canarygrass strains from diverse latitudinal origins in broadcast-seeded plots. Left and right plots in foreground are cultivars Venture and Ioreed, respectively, adapted generally at 41° to 44° N. in the U.S. Midwest; center plot is Rovik from 69° to 70° N. in northern Norway. Experiment 4; planted 24 May 1984, photo 16 June 1985.*

Canada (Porsild and Cody, 1980) and evaluating those in Alaska along with a broader spectrum of introductions from northern Scandinavia and the USSR (Hulten, 1968).

Because of historical agricultural activities in the vicinity of Fort Simpson, it was not known by Mr. Watsyk whether the seed collection from there represented a truly indigenous ecotype or a naturalized strain introduced by human activity from more southern sources. If artificially introduced to the Fort Simpson area at some uncertain earlier time, the superior performance of that ecotype in the present experiment suggests that natural selection pressures characteristic of that northern latitude have altered the original genotype toward superior adaptation to north-latitude climatic influences (Klebesadel, 1985b). In the new environment, such introductions are genotypically modified by unaccustomed natural selection pressures, during several to many generational cycles of gene sorting, toward enhanced physiologic harmony with the unique climatic characteristics of the more northern latitude (Klebesadel, 1985b). Regardless, whether native to the area or artificially introduced and benefiting from recent adaptive modification, it is apparent that the Fort Simpson ecotype possesses an inherent genetic constitution that confers a level of winter-hardiness for this subarctic area superior to that displayed by more southern-adapted North American strains and cultivars.

General inspection of the experiment in spring of 1988 showed no additional winterkill of plants during the second winter. Plants of Rovik exhibited somewhat more active spread (by rhizome growth) and produced more seed heads than those of Hansvoll. Plants of the most vigorously spreading cultivars (Garrison, Manchar, etc.) were coalescing and individual-plant identity was disappearing; therefore, no further data were taken and the experiment was terminated.

Source	Strain	Latitudinal adaptation or origin	Winter survival spring 1987	Vigor rating[1]
Reed canarygrass:		°N	%	
Norway	Rovik	69-70	100 a[2]	1.5 abc
	Hansvoll	69-70	100 a	1.7 bc
Canada	"Ft. Simpson"	61.6	99 a	4.6 d
	Common	44-52	96 a	6.6 e
	Castor	44-52	84 b	7.4 f
	Grove	44-52	76 b	7.5 fg
	Frontier	44-52	75 b	7.8 fg
USA	Flare	41-44	94 a	6.9 e
	Palaton	41-44	83 b	7.8 fg
	Vantage	41-44	82 b	7.8 fg
	Venture	41-44	77 b	8.0 g
	MN-76	43-48	40 c	8.6 h
Other grasses:				
Norway	Engmo timothy	69-70	100 a	1.8 bc
	Lavang Kentucky bluegrass	69-70	100 a	1.3 ab
Alaska	Polar bromegrass	61-62	100 a	1.3 ab
	Arctared red fescue	61-62	100 a	1.3 ab
	Nugget Kentucky bluegrass	61-62	100 a	1.4 abc
	Pumpelly bromegrass[3]	61-62	100 a	1.5 abc
	Norcoast hairgrass	61-62	100 a	1.7 bc
Canada	Dormie Kentucky bluegrass[4]	69	100 a	1.2 a
	Carlton bromegrass	41-44	100 a	1.7 abc
USA	Garrison creeping foxtail	45-52	100 a	1.6 abc
	Manchar bromegrass	43-47	100 a	1.8 c

[1] Means of ratings in June 1987 of all living plants: 1 = excellent survival and vigor, 9 = minimal vigor, barely alive.

[2] Within each column, means not followed by a common letter are significantly different (5% level) using Duncan's Multiple Range Test.

[3] Composited line representing several indigenous Alaskan collections.

[4] Selected in Canada from germplasm originating in the Murmansk region of the USSR (69°N).

Table 4. *Percent winter survival and vigor ratings of surviving plants of 12 reed canarygrass strains from diverse latitudinal origins, and 11 winterhardy comparison grasses grown as individual plants in an exposed location at the Matanuska Research Farm (61.6°N). Experiment 5; planted 24 May 1986.*

Figure 12. *Comparative winter survival and vigor of various strains of reed canarygrass grown as individual plants in rows. Photograph taken 3 June 1987 of rows seeded 24 May 1986. Note excellent survival and superior vigor of plants of ecotype from Ft. Simpson (61.9°N.), more similar to the Norwegian strains Rovik and Hansvoll than to the North American cultivars Palaton, Flare, Castor, and Frontier adapted at more southern latitudes.*

Experiment 6: *Influence of (a) Removal of Aerial Growth Following Seed Harvest, and (b) Time of Nitrogen Application on Seed Production of Rovik Reed Canarygrass.*

This experiment was of a short-term, exploratory nature and is summarized here because no previous research has been conducted on seed production of reed canarygrass in Alaska. Therefore, the results may serve as a basis for future, more comprehensive investigations.

The rows of Rovik seeded 1 June 1984 for seed increase established well. In late August or early September of 1984, much of the leafy herbage in the central area of the planting was grazed by moose; a grazed stubble of 4-to-8 inches was left on plants that had been 12-to-16 inches tall.

Growth on the rows was left intact during the winter 1984-85. In late December, 1984 and early January, 1985, several days of warm (+30° to +46°F) wind melted the snow cover which refroze as a relatively uniform layer of ice 1 to 3 inches thick over the rows. The ice remained in place for several weeks.

Heading of the grass was very sparse in 1985 and seed production from the entire area was at the rate of only 8 lb/acre. Heading was consider-

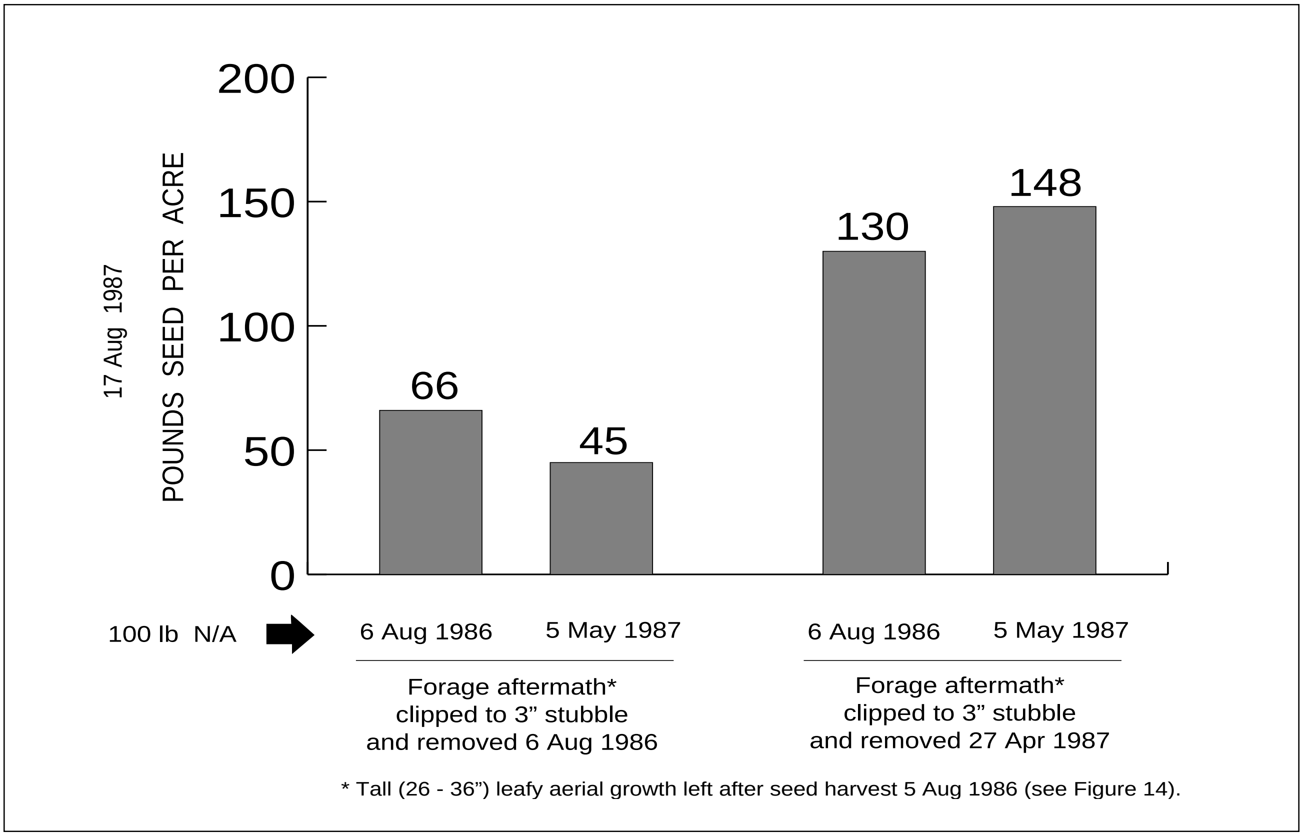


Figure 13. *Seed yields of Rovik reed canarygrass in August 1987 as influenced by time of nitrogen fertilizer application and time of clipping and removal of aerial growth left after 5 August 1986 seed harvest. L.S.D. (5% level) = 45 lb/acre.*

ably greater in 1986, though still modest, and seed yield that year was at the rate of 38 lb/acre.

Following the four treatments imposed in August of 1986, seed yields differed considerably in 1987 (Figure 13). Leaving the tall herbage in place after seed harvest (Figure 14) was clearly superior to clipping and removing that growth, regardless of whether N fertilizer was applied in August or the following May. The differences engendered by time of N application were not significant within either scheme of aftermath management, and time of N application had much less effect on seed yield than did leaving versus removing the aerial growth after the 1986 seed harvest.

Harvest of the tall, leafy aerial growth left after seed harvest (Figure 14) would provide a considerable yield of modest-quality forage. However, since even the most winter-hardy reed canarygrass strains are marginally winter-hardy at this location, and because removal of the aerial growth following seed harvest suppressed seed yield the following year, it may be desirable to leave the straw-like growth in place all winter. This growth would hold snow in place against the strong evacuation force of winter winds, thereby providing insulation and protection of plants from winter stresses.

It cannot be determined with certainty from the present results whether (a) harvest of the aerial growth, and thereby the interruption of growth processes in the plants, or (b) winter protection afforded by the straw-like growth over winter, was most effective in causing the large differences in seed yields in 1987. It is believed that the former was most influential because the experiment was located adjacent to a tree barrier that suppressed the force of winter winds; therefore, snow cover should have remained relatively uniform over all plots.

Harvest of the aerial growth on 6 August 1986 removed all of the foliage leaving only a bare stubble. It is known that the changing photoperiod/nyctoperiod regime during late summer and autumn exerts a major influence on subsequent winter survival and heading of perennial grasses

Figure 14. *Appearance of plots of Rovik reed canarygrass in Experiment 6 on 6 August 1986. Plot at left shows tall, leafy growth left in place after seed harvest on 5 August. Two plots to right of center were clipped to 3" stubble and aerial growth removed. Center plot is being topdressed with nitrogen fertilizer.*

at this northern latitude (Klebesadel, 1971). To be effective on plant responses, the photoperiod/ nyctoperiod influences require the presence of leaves as receptor tissues. Therefore, removal of all leaf growth in early August probably deprived plants of the ability to respond to these critical environmental influences, resulting in low seed yield in 1987 (Figure 13). Some support for this viewpoint is seen in the slightly (though not significantly) increased seed yield in 1987 (66 lb/acre vs. 45 lb/acre) where nitrogen was added when the top growth was removed in August 1986 versus no N applied. That fertilization stimulated growth of tillers and appearance of leaves during autumn of 1986 over that seen on clipped plots where no N was applied until spring of 1987. That increased leaf growth could have served as receptor tissue favoring plant response to the photoperiod/nyctoperiod stimulus during late summer and autumn of 1986 resulting in slightly increased seed production in 1987.

Evans and Ely (1941) reported that macroscopic initiation of seed heads in reed canarygrass occurred about the middle of April in northern Ohio. In contrast, Hodgson (1966) noted that many northern-adapted perennial grasses initiate seed head development during autumn in Alaska, and those macroscopic, incipient seed heads then overwinter below the soil surface to be elevated and emerge during the subsequent growing season.

It is not known to what extent the above observations relate to northern-adapted reed canarygrass grown at high latitudes, but the significance to heading and seed production should be investigated.

The very disappointingly low yields of seed in 1985 and 1986 may be due in large measure to low levels of N applied. Alternatively, seed rows of this species may not reach full yield potential until the second or third year of growth. Future investigations are obviously needed to define optimum management procedures for assured high seed yields from this species in Alaska. Variables evaluated should include time of planting, row spacing, times and rates of fertilizer application, different times of forage (or straw) harvest following seed harvest, and various stubble heights left at harvest.

Conclusions

The results reported here represent a significant advance in our knowledge of the range of winter-hardiness in reed canarygrass, and provide the informational basis for expanded utilization of this species in Alaska. The generally good performance in these trials of reed canarygrass strains originating from above 61°N reveals that levels of winter-hardiness exist within this species considerably superior to the inadequate levels found in the more southern-adapted North American strains.

Although Rovik and Hansvoll from northern Norway and the Fort Simpson ecotype were less winter-hardy than several cultivars compared in other species, both were markedly hardier than any of the 10 North American reed canarygrass strains and several other accessions compared from northern Europe. These results parallel and reinforce earlier findings within other species (Klebesadel, 1984, 1985a, 1985b; Klebesadel et al., 1964; Klebesadel and Helm, 1986) confirming that best winter survival in Alaska is achieved with ecotypes from far-northern origins, especially from northern areas where winter stresses are relatively severe.

The present results suggest that evaluations of these far-north-adapted strains of reed canarygrass should be expanded in Alaska. Range maps and statements reveal that the northern limit of (native?) distribution of reed canarygrass in North America reaches Great Slave Lake (about 62° N) in Canada (Porsild and Cody, 1980); additional ecotypes from that area, if native, should possess inherent northern adaptation and be tolerant of severe winter stresses as well.

In Europe the species occurs in Norwegian, Swedish, and Finnish Lapland (Alway, 1931; Hulten, 1968) and on the Kola Peninsula of the USSR at 66° to 70° N (Hulten, 1968). Those areas are considerably north of the North American origins of reed canarygrass strains that have been non-hardy in this area of Alaska. A greater representation of germplasm from the northernmost portions of the range of the species in both hemispheres should be sought and evaluated in Alaska.

Further evaluations of an array of such northern-adapted ecotypes should identify and assemble a base of winter-hardy reed canarygrass germplasm for dependable use in Alaska. When this is accomplished, selection for other desirable agronomic, palatability, and nutritional criteria can proceed within that reservoir of adapted materials. Moreover, more extensive plantings of superior strains should proceed in other agricultural areas of Alaska to determine performance beyond the area of these experimental trials. These steps will permit a much more realistic assessment of the potential usefulness of reed canarygrass in Alaska.

The observed capacity of several strains that sustained considerable winter injury to recover and fill decimated stands reveals a valuable characteristic in reed canarygrass. Stands estimated at only 10% to 40% winter survival in Experiments 2 and 3 were seen to revive and thicken to much fuller stands during one year of recuperation. Whether utilized for forage or for soil stabilization, recovery and filling of injured, thinned stands by rapid spread of rhizomes is a desirable attribute that can circumvent the need to till and replant.

The exploratory experiment on seed production provided both answers and questions. Clipping and removing the aerial growth in early August following seed harvest clearly suppressed seed yield the following year. However, even the best treatment resulted in seed yield of only 148 lb/acre, considerably less than yields from this species reported by others (Baltensperger and Kalton, 1958; Marten, 1985; Wilkins and Hughes, 1932). Further evaluation of managerial practices should be pursued to identify those required to maximize seed yields of adapted reed canarygrass in this area.

Acknowledgments

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